RECENT FORAMINIFERA OF ST. ANDREW BAY, FLORIDA

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ABSTRACT

Foraminiferal analysis was conducted on 403 bottom samples from St. Andrew Bay, a polyhaline to ultrahaline estuary on the northwest coast of Florida. Intertidal samples (140) and subtidal samples (263) were collected by the National Marine Fisheries Service during November 1974 and April 1975. Water properties samples were collected also at 69 of the subtidal stations. Foraminiferal concentrates were obtained by carbon tetrachloride float from an undisturbed, upper one cm (0.4 in.) of tube (intertidal) and grab (subtidal) samples. Populations were censused by random, 300-specimen counts. Eighty-four species, including four pairs of subspecies, were recognized; none are new. Biofacies were based on percentages of populations and geographic distribution patterns.

The genus *Ammonia* dominates foraminiferal populations at 75 percent of the statistically valid stations (stations with 300 or more foraminifera) and forms the only major biofacies of the Bay. *Ammonia parkinsoniana tepida* and *typica* are the dominant *Ammonia.* The smaller and more fragile *A. parkinsoniana tepida* is dominant in intertidal areas, where salinity and temperature are lower. The salinity and temperature relationships of these ecophenotypes are the same as reported for San Antonio Bay, Texas, but the bathymetric relationships are reversed. The ecophenotypes define secondary biofacies within the major one.

Several species characteristic of the continental shelf occur in widely varying percentages, but with a definite geographic pattern, along the deepest and most central parts of the Bay. It is suggested that this secondary biofacies reflects the effect of flood tidal action on meroplanktonic larval stages of the species.

The remaining 25 percent of the stations are dominated by *Elphidium*, miliolids, *Ammobaculites, Nonionella, Miliammina, Rosalina,* and *Trochammina,* which occur erratically in abundance and distribution. *Elphidium* shows the greatest adaptability to pollution. There appears to be no biologic relationship between bottom sediment and foraminifers.

INTRODUCTION

St. Andrew Bay is situated in the northwestern part of the Florida Panhandle, on the northeastern shore of the Gulf of Mexico between coordinates 85°36′ and 85°45′W longitude and 30°14′ and 30°11′N latitude. The name has been applied to a complex of bays, including West Bay, East Bay, North Bay, and St. Andrew Bay proper (Grady, 1981; Figure 1), but will be used here only for the individual bay, which is the southern, most coastal bay of the estuarine system. Grady (1981) divided St. Andrew Bay into West Arm, East Arm, Central Bay, and lagoon. A fifth designation, bayous, which includes all of the indentations off the Bay, such as Watson Bayou, was also used by Grady, (1981; Figure 2). St. Andrew Bay is approximately 5.5 km (3.41 mi) long and 4 km (2.48 mi) wide with a southeast to northwest long axis orientation.

St. Andrew Bay is a drowned stream valley. The valley was eroded during Pleistocene and inundated by post Pleistocene transgression. The shoreline complex that forms Shell Island has been interpreted (Vernon, 1942, p. 19) as another product of the transgression, but Otvos (1973, p. 18) considers it a result of earlier Sangamon interglacial transgression and part of a succession of such features along the Gulf Coast.

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PROCEDURE

Samples used in this study were collected by the National Marine Fisheries, SEFC, Panama City Laboratory under the direction of Grady. They were collected in three operations: by small boat from intertidal localities; by the R/V Kingfish II on November 11-14, 1974 (West Arm); and by the R/V Kingfish II on February 10-14, 1975 (East Arm, Central Bay, lagoon, and the bayous).

Sediment and foraminiferal samples were collected with a Van Veen Grab. Foraminiferal samples were obtained from undisturbed surfaces with a spatula to about ¼ inch depth. Samples were stained by Rose Bengal immediately after recovery on the boat. Once ashore the samples were dried, sieved (63 microns), and immersed in carbon tetrachloride. The foraminiferal residues obtained are the only populations studied. Skill in recognition of significant rose stain was not attained; consequently no distinction between stained and unstained specimens was made.

Water samples were collected with a Van Dorn sampling bottle. Four polyethylene bottles (250 ml, 7.5 fluid oz) were filled at selected depth intervals. Bottom temperatures were determined with a Yellow Spring Model 47 scanning telethermometer. Salinity was determined in the laboratory on a Beckman induction salinometer, Model RS7-B.

Random counts of 300 foraminiferal tests were made from the foraminiferal residues, and percentages determined. Stations with 300 or more foraminiferal specimens were considered statistically valid. Eighty-four species, including four pairs of subspecies, were recognized; none are new.

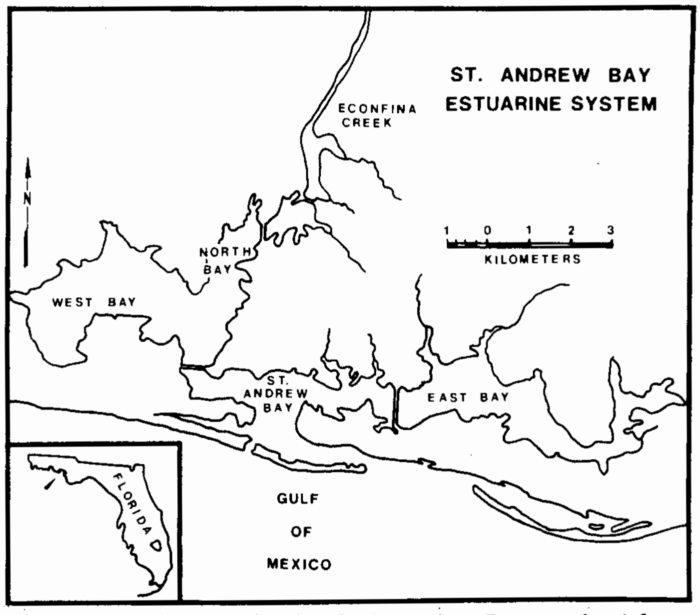

Figure 1. Location map showing the St. Andrew Bay complex (after Grady, 1981).

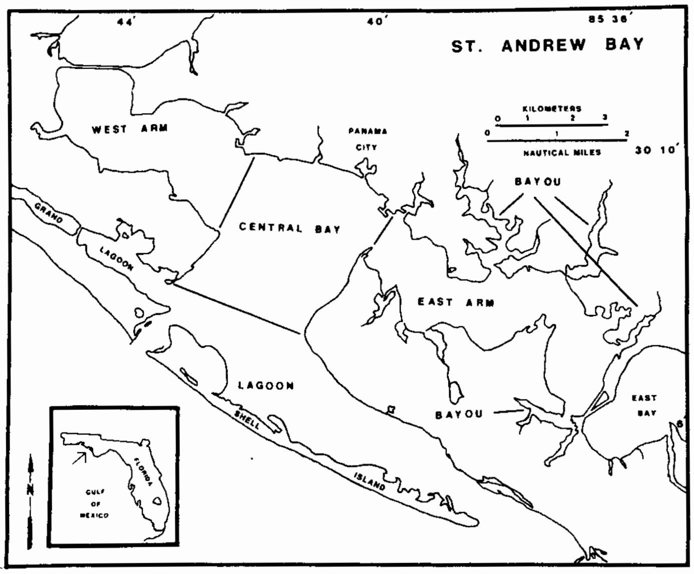

Figure 2. Subdivisions of St. Andrew Bay (after Grady, 1981).

Biofacies were defined by taxa or taxal groups that comprise a majority of the populations at the 295 statistically valid stations and form a geographic pattern. Secondary biofacies were defined by taxa or taxal groups that are a minority at all of the stations but also form a geographic pattern. Secondary biofacies are superimposed on, although not exclusively confined to the principal biofacies areas. Significant taxa are taxa or taxal groups that form only minor components of most populations and have no geographic pattern of occurrence but, nevertheless, are of interest. Rare species are those which seldom exceed 1 percent of the population and occur at fewer than 13 stations.

ECOLOGIC FACTORS

St. Andrew Bay attains a maximum depth of 19.81 m or nearly 65 ft (National Oceanic and Atmospheric Administration, 1973). The deeper areas occur in the centers of East Arm and West Arm (Figure 3) where tidal velocity may be the critical factor. Sediment in the Bay ranges from coarse sand to clay (Figure 4). Quartz constitutes the majority of the sediment; quartz silt is concentrated in the deeper areas of St. Andrew Bay and in Watson Bayou, located north of East Arm.

Salinity and temperature data were collected by the R/V Kingfish II during November 1974, and February 1975. No intertidal temperature and salinity data were collected.

Bottom salinities from the November 11-14, 1974, cruise ranged from 30.61 per mil in the south part of West Arm to 33.98 per mil on the northwest side of Shell Island where the Bay opens into the Gulf (Figure 5). These salinities are ultrahaline. Bottom salinities during the February cruise ranged from 21.53 per mil in the south part of West Arm to a high of 34.72 per mil on the northwest side of Shell Island (Figure 6). These salinities range from polyhaline to ultrahaline.

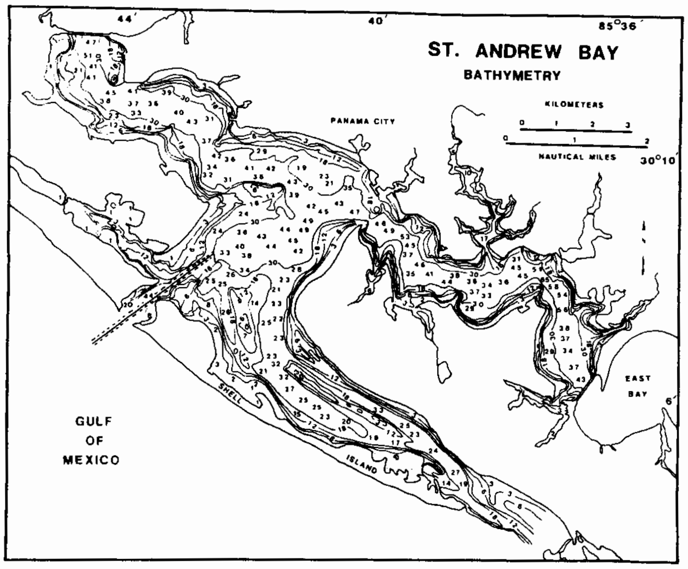

Figure 3. Water depths of St. Andrew Bay (after National Oceanic and Atmospheric Administration, 1973).

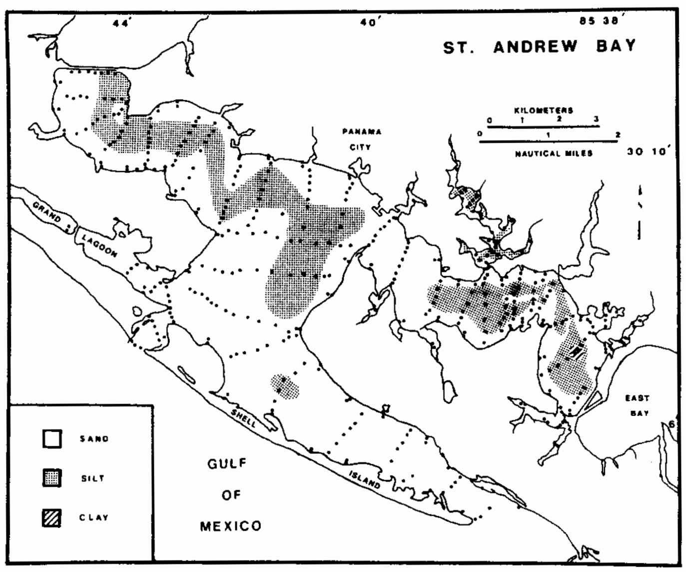

Figure 4. Map of bottom sediments in St. Andrew Bay.

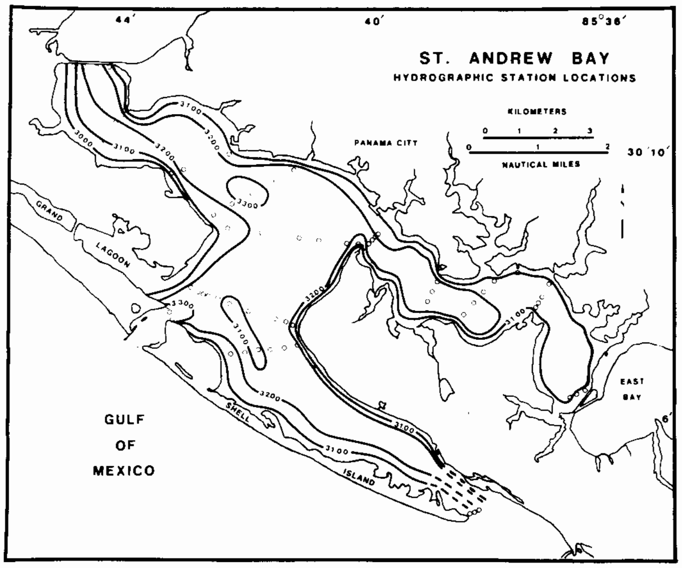

Figure 5. Map of bottom salinity at St. Andrew Bay; collected on November 11-14, 1974.

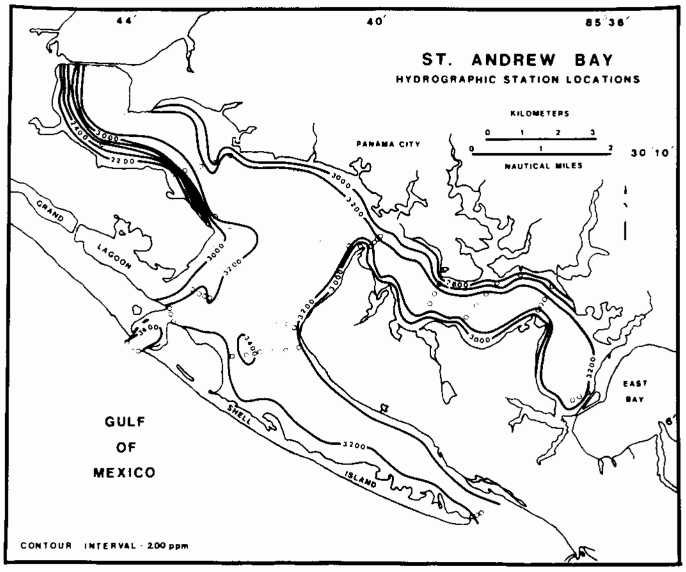

Figure 6. Map of bottom salinity at St. Andrew Bay; collected on February 10-14, 1975.

Bottom temperatures taken on the November cruise ranged from 18.40 °C (65.12 °F) in the northernmost part of West Bay to 21.80 °C (71.24 °F) northwest of Shell Island (Figure 7). During February, temperatures ranged from 15.50 °C (59.90 °F) in the lower south central part of the Bay to 17.90 °C (64.22 °F) in the south extension of East Arm (Figure 8). Both temperature and salinity were generally lower in interdidal areas and increased toward the central areas.

BIOFACIES

Ammonia Biofacies

The genus *Ammonia* dominates the foraminiferal populations in 75 percent (221 of 295) of the statistically valid St. Andrew Bay samples (Figure 9). The average percentage of *Ammonia* in this biofacies is 60 percent and varies from 21 percent to 97 percent. The *Ammonia* dominant assemblage has a relatively small and variable taxonomic diversity averaging 17 species and varying from 5 to 37 species per sample. Minor taxa of the *Ammonia* biofacies include several species of *Elphidium,* miliolids, and agglutinated forms.

The *Ammonia* predominant biofacies is an established biofacies of shore-line and inshore waters of subtropical to low temperate latitudes. Parker et al (1953) considered *Ammonia* (cited as *Rotalia)* to be a typical open Gulf species that invades bay environments from open Gulf waters. Bandy (1954, 1956), Phleger (1960), and Phleger and Parker (1951) noted that *Ammonia* is a prominent member of their shoreline assemblages. Studies of coastal bays, lagoons, and estuaries of the Gulf of Mexico have shown that the *Ammonia* dominated biofacies are both consistent and widespread (Ayala-Castañares, 1963; Bandy, 1956; Kane, 1967; Lamb, 1972; Parker et al, 1953; Pastula, 1967; Phleger, 1960; Poag, 1976, 1978; Segura-Vernis, 1977; Waldron, 1963; Walton, 1964; Wantland, 1969). Judging from its abundance, *Ammonia* is well suited to the conditions of St. Andrews Bay.

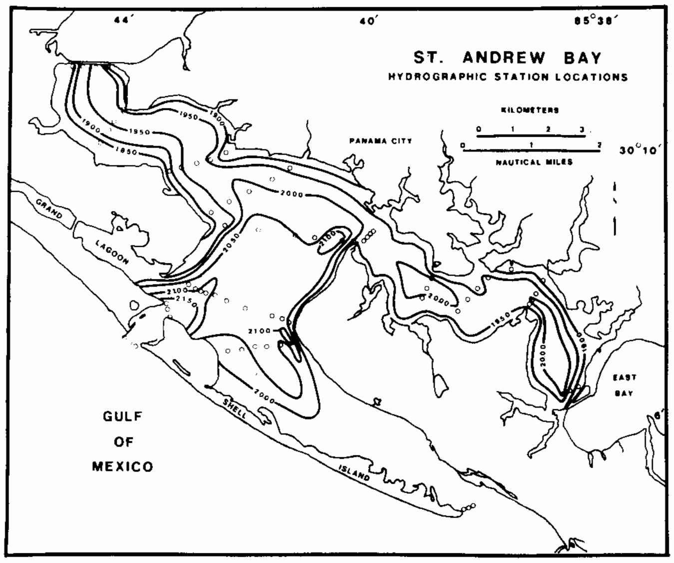

Figure 7. Map of bottom temperatures at St. Andrew Bay; collected on November 11-14, 1974.

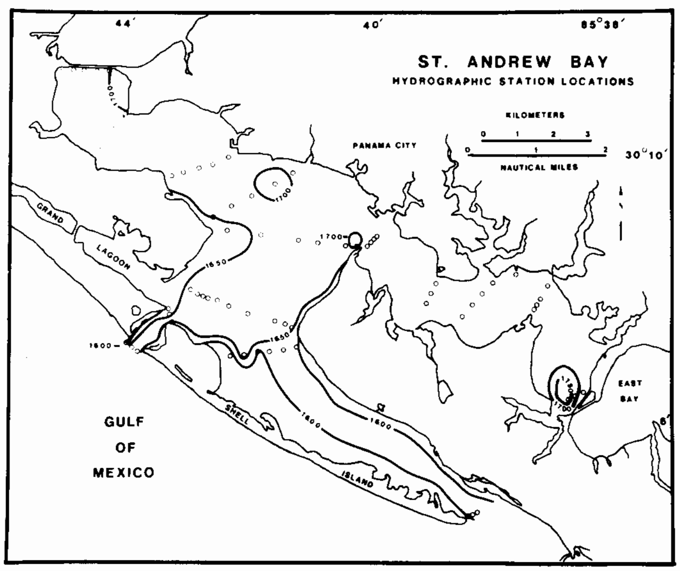

Figure 8. Map of bottom temperatures at St. Andrew Bay; collected on Februrary 10-14, 1975.

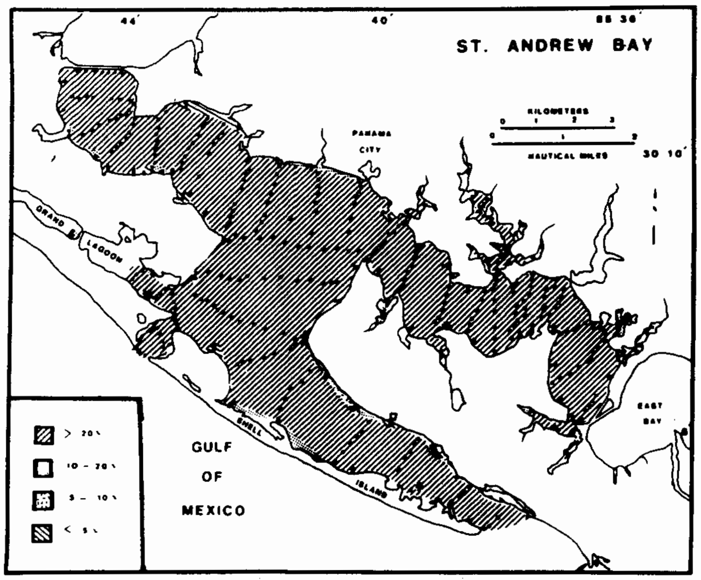

Figure 9. *Ammonia* distribution map.

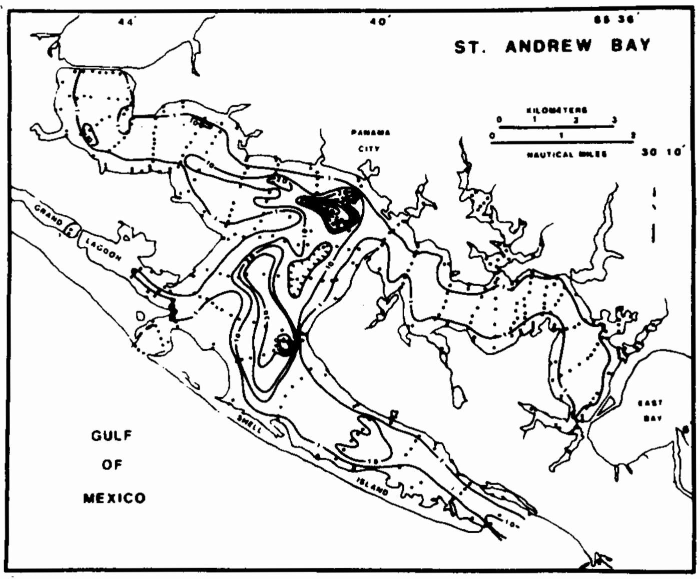

Figure 10. Ratio map comparing *Ammonia parkinsoniana* (d'Orbigny) forma *tepida* Cushman to *Ammonia parkinsoniana* (d'Orbigny) forma *typica* Poag.

Bottom salinities measured in St. Andrew Bay in the November (Figure 5) and in the February (Figure 6) cruises were optimal for *Ammonia* growth (Bradshaw, 1957). Bottom temperatures (Figures 7 and 8) are below Bradshaw's (1957) optimal range for *Ammonia* growth and reproduction, however, except in November when a temperature of over 20 °C (68 °F) was reached. Paog (1978), though, found temperatures ranged from 25 °C (77 °F) in November to 12 °C (53.6 °F) during April, in San Antonio Bay, Texas, where *Ammonia* is abundant. His study indicates a broader temperature tolerance for *Ammonia*. In San Antonio Bay the *Ammonia* dominated biofacies occurs in a variety of sediments ranging from coarse to very fine silt.

The *Ammonia* biofacies covers all of St. Andrew Bay except a few scattered intertidal localities and the bayous. It includes many taxa other than *Ammonia* and its species, as will be discussed below.

Ammonia parkinsoniana (d'Orbigny) forma tepida Secondary Biofacies

Two ecophenotypes of *Ammonia, Ammonia parkinsoniana* (d'Orbigny) formas *tepida* Cushman (Plate 1, Figures 1-3) and *typica* Poag (Plate 1, Figures 4-6) make up most of the *Ammonia* populations, These ecophenotypes were used to define secondary biofacies.

Ammonia parkinsoniana tepida is predominant in 59 percent (131 of 221) of the *Ammonia* dominant samples. In the 131 samples, this species averages 44 percent of the total population and varies from 13 percent to 76 percent. Faunal diversity varies from 11 to 37 species and averages 19 species per sample.

Ammonia parkinsoniana tepida is more abundant in the central areas of the Bay, whereas *A. parkinsoniana typica* generally is the more dominant toward and in the intertidal areas (Figure 10). Consequently, concentrations of *A. parkinsoniana tepida* occur in areas of higher salinity and temperature, whereas *A. parkinsoniana typica* is more abundant in areas of lower

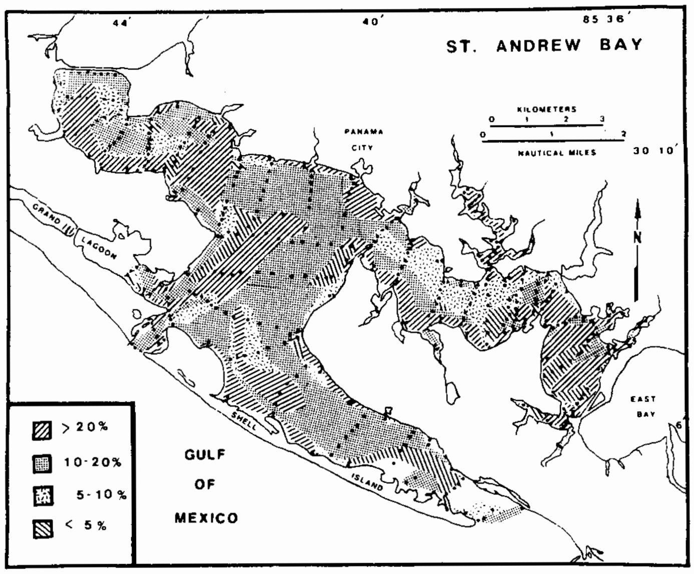

Figure 11. *Elphidium* distribution map.

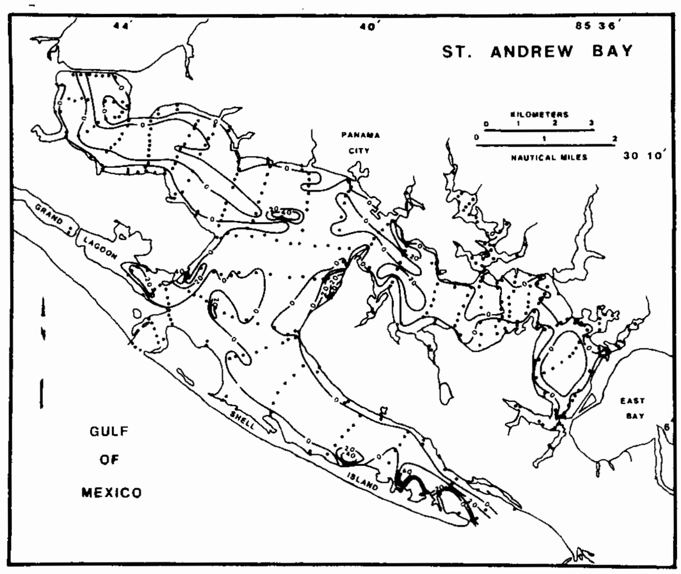

Figure 12. Contour map of miliolids in the *Ammonia* biotype.

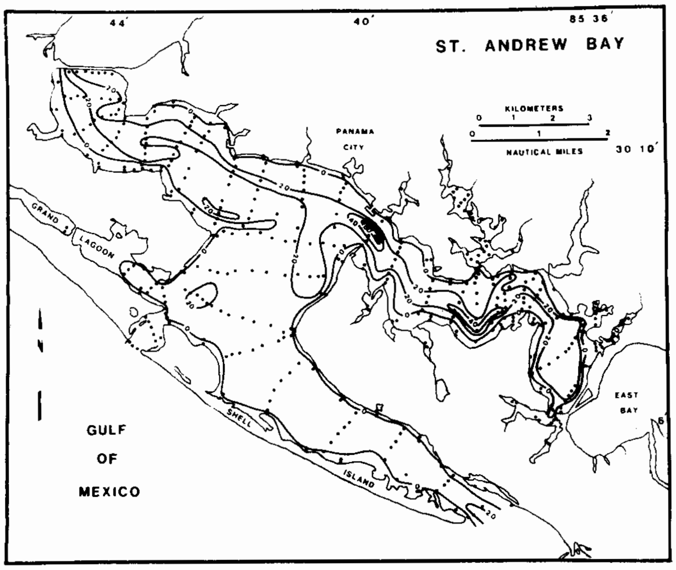

Figure 13. Contour map of shelf fauna.

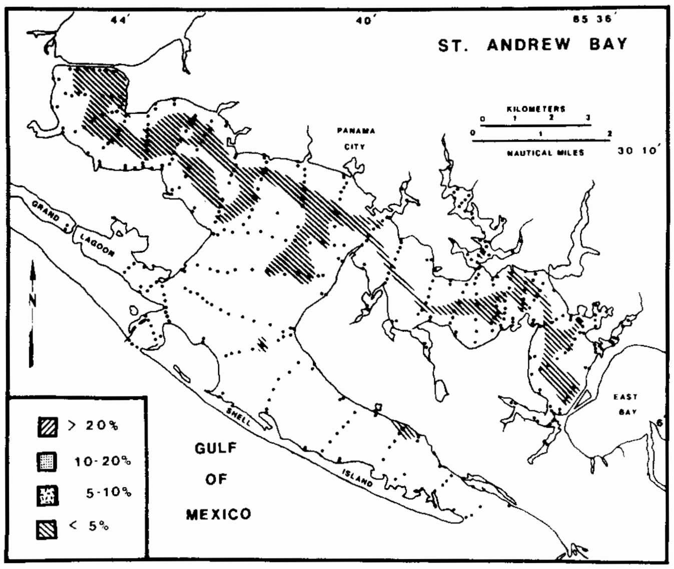

Figure 14. *Hopkinsina* distribution map.

salinity and temperature. Poag (1978) reported similar relations to the salinity and temperature in San Antonio Bay, Texas, but in San Antonio Bay, the salinity and temperature minimums occur in the central and deeper parts of that bay. The distribution of the two ecophenotypes is well shown by mapping the *A. parkinsoniana tepida* to *A. parkinsoniana typica* ratio (Figure 10). The *A. parkinsoniana tepida* secondary biotope coincides with the subtidal areas of St. Andrew Bay.

Ammonia parkinsoniana (d'Orbigny) forma typica Secondary Biofacies

Ammonia parkinsoniana (d'Orbigny) forma *typica,* is the dominant *Ammonia* ecophenotype in 41 percent (90 of 221) of the *Ammonia* dominant samples. Where dominant, this ecophenotype averages 56 percent of the total foraminiferal population and ranges from 21 percent to 94 percent in the individual samples. The faunal diversity averages 12 species per sample and varies from 5 to 20 species. This secondary biofacies is dominant in the intertidal areas of the Bay.

SIGNIFICANT TAXA

The *Ammonia* biofacies and its component secondary biofacies include many species other than those of *Ammonia.* They are discussed in taxa and taxal groups in order to generalize their relations to ecologic factors and the primary and secondary biofacies.

Elphidium is the second most abundant and widespread genus in St. Andrew Bay. It is the dominant genus in 10 percent (30 of 295) of the stations, and is the second most dominant in 59 percent (130 of 221) of the stations. However, the distribution seems without relation to depth, salinity, etc., except for an apparent, ill-defined abundance along the shorelines (Figure 11). Examination of the species suggests that some of this is due to differences in the preferred ecologic factors. For example, *Elphidium fimbriatulum* (Cushman) (Plate 1, Figures 13-14) and *Elphidium disconidale* (d'Orbigny) forma *translucens* Natland are typically shelf forms whose presence in St. Andrew Bay is funadmentally unusual, as is argued for the Shelf Fauna below. On the other hand, the distribution of *Elphidium poeyanum* (d'Orbigny) (Plate 1, Figures 11-12) suggests that it is a minor, but natural element of the subtidal *Ammonia parkinsoniana tepida* secondary biofacies.

The most abundant *Elphidium* are *Elphidium galvestonense* Kornfeld forma *mexicanum* Kornfeld (Plate 1, Figures 9-10) and *E. gunteri* Cole forma *salsum* Cushman and Brönniman (Plate 1, Figures 7-8), which favor less saline and cooler water elsewhere, and *E. galvestonense* Kornfeld forma *typicum* Poag and *E. gunteri* Cole forma *typicum* Poag, which favor more saline and warmer water (Poag, 1978). It is true that formas *E. gunteri salsum* and *E. galvestonense mexicanum* occur in higher percentages in intertidal stations and seem a natural component of the intertidal secondary biofacies, but they also are prominent (e.g., above 20 percent of the total population) at some stations in the central part of Central Bay and the lagoon. Furthermore, their counterparts, *E. galvestonense typicum* and *E. gunteri typicum,* are rare in the more saline central bay areas but do occur abundantly in some intertidal stations. Lastly, some of the greatest abundances of *Elphidium* occur in polluted bayous, such as Watson Bayou, and along the shoreline of East Arm. The rapid and erratic variation in the abundance of these formas confounds a simple interpretation of relation to environmental factors. Although their abundance in the intertidal areas produces the slight shoreline trend on the *Elphidium* map (Figure 11) and ties them more closely to the intertidal subfacies, the *E. gunteri salsum* and *E. galvestonense mexicanum* formas must be included in the subtidal secondary biofacies faunal list also because of the several stations at which they are prominant. The *E. gunteri typicum* and *galvestonense typicum* formas should be confined to the intertidal secondary biofacies.

Miliolid species make up the third most abundant taxal group in St. Andrew Bay. They are dominant at 9 percent (28 of 295) of the statistically valid stations and average 59 percent of the population at those stations. Miliolids are the second most abundant species in 14 percent of the *Ammonia* dominant stations (Figure 12) where they average 21 percent of the populations. The distribution of miliolids shows no geographic pattern or relationship to ecologic factors. The miliolid group includes many more species than preceding taxal groups. They are listed below according to their apparent adaptations to the ecology and biofacies of St. Andrew Bay.

All the miliolids with the exception of *Wiesnerella auriculata*

Egger are bay forms. The number of miliolid species present is much larger than that of *Ammonia* and *Elphidium*, but the total number of miliolids is usually less than 5 percent of a population. Exceptions are mostly in intertidal areas. Some of the species favor intertidal areas, but most occur in subtidal areas as well; consequently they must be considered natural components of the *Ammonia* biofacies rather than of the secondary biofacies.

More common or abundant in intertidal areas.
Cornuspira planorbis Schultz, *Quinqueloculina bosciana* d'Orbigny, *Q. rhodiensis* Parker, *Triloculina linneiana* d'Orbigny *comis* Bandy, *T. striatigonula* Parker and Jones, and *T. variolata* d'Orbigny.

Most common or abundant in subtidal areas.
Quinqueloculina bicarinata d'Orbigny, *Q. poeyana* d'Orbigny, *Triloculina brevidentata* Cushman.

Widespread in both intertidal and subtidal areas.
Quinqueloculina horrida Cushman Poag, *Q. seminulum* (Linné), *Q. seminulum jugosa* Cushman, *Triloculina fiterrei meningoi* Agosta, *T. oblonga* (Montagu), *T. sidebottomi* (Martinotti)?.

Less than 1 percent and observed at fewer than 13 stations.
Massilina inaequalis Cushman, *Mioliolinella circularis* (Brönnimann) *M. labiosa* (d'Orbigny), *Quinqueloculina bidentata* d'Orbigny, *Q. tropicalis* Cushman, *Spiroloculina soldanii* Fornasini forma *dentata* Cushman and Todd, *Spiroloculina soldanii* Fornasini forma *typica* Poag, *Wiesnerella auriculata* (Egger).

Agglutinated forms are uncommon and typically intertidal. They are dominant at 5 percent (14 of 295 stations) of which all are intertidal.

Ammobaculites (*A. salsus* Cushman and Brönnimann and *A. exiguus* Cushman and Brönnimann) is dominant at 9 stations; *Miliammina fusca* (H.B. Brady) is dominant at 3 stations; *Trochammina inflata* (Montagu) is dominant at 2 stations. Also present but not dominant are *Arenoparrella mexicana* (Kornfeld), *Lagenammina atlantica* (Cushman), *Textularia earlandi* Parker, *Tiphotrocha comprimata* (Cushman and Brönnimann), and *Trochammina lobata* Cushman. Rare forms present in less than 1 percent and fewer than 13 stations are *Haplophragmoides manilaensis* Andersen, *Textularia mayori* Cushman, *Textularia secasensis* Lalicker and McCullock, and *Trochammina compacta* Parker. *Bigenerina irregularis* Phleger and Parker is included with the Shelf Fauna.

Miliammina occurs mainly at intertidal stations, but the other species occur at both intertidal and subtidal stations. Along with *M. fusca, Ammobaculites salsus, A. exiguus, Arenoparrella mexicana,* and *Trochammina inflata* were assigned to the intertidal, less saline and cooler water, *Ammonia parkinsoniana typica* secondary biofacies. *Lagenammina atlantica* was assigned to the subtidal, *Ammonia parkinsoniana tepida* secondary facies. *Textularia earlandi, Tiphotrocha comprimata* and *Trochammina lobata* were assigned to the *Ammonia* biofacies.

SHELF FAUNA

The foraminiferal community of St. Andrew Bay includes highly variable percentages (typically less than 1 percent but rarely up to 60 percent) of a large number of species that are generally considered to be typical of the shelf environment (Figure 13). The occurrence of the species changes from station to station but often forms an axial geographic pattern in the Bay.

The presence of established shelf species in bays has been reported often (Ayala-Castañares, 1963; Benda and Puri, 1962; Lamb, 1972; Lynts, 1962; Otvos, 1978; Parker et al, 1953; Pastula, 1967; Phleger and Lankford, 1957; Poag, 1976; Post, 1951; Segura-Vernis, 1977; Walton, 1964). Generally speaking, it is hard to tell from older reports whether the author believed a particular species to be well adapted to both slightly subnormal and normal (e.g., 30-34 per mil) salinities or simply able to survive poorly in the lower salinities of the bay. Flood tidal transport has been suggested to be the mechanism of displacement into the bays instead of biologic invasion (e.g., Otvos, 1978). The recent establishment of meroplanktonic stages for *Brizalina lowmani* (Hueni et al, 1978) increases the potential of flood tidal transport of shelf forms into bays and provides a mechanism for the miniscule replenishment of the shelf species, in spite of their poor adaptability and survival.

Many species and the shelf fauna as a whole increase toward central parts of the Bay (Figure 3), where salinity and temperature are highest and flood tidal currents should also be highest. Some species (e.g., *Hopkinsina pacifica* Cushman; Plate 2, Figures 9-10) show an axial pattern of occurrence extending from East Arm to West Arm (Figure 14).

As a group, species of the shelf fauna are subtidal, but they are questionably viable aliens to that environment and are not included in the biofacies faunas listed above. They are listed below in categories resulting from examination of literature and distribution in St. Andrew Bay.

Typical Shelf Forms.
Bigenerina irregularis Phleger and Parker, *Brizalina lowmani* (Phleger and Parker) (Plate 1, Figures 15-16). *B. striatula* (Cushman) (Plate 1, Figures 17-18), *Bulimina marginata* d'Orbigny, *Elphidium fimbriatulum* (Cushman) (Plate 2, Figures 13-14), *Fursenkoina pontoni* (Cushman) (Plate 1, Figures 19-20), *F. spinicostata* (Phleger and Parker) (Plate 2, Figures 1-2), *Globocassidulina subglobosa* (Brady), *Guttulina australis* (d'Orbigny) (Plate 2, Figures 11-12), *G. lactea* (Walker and Jacob), *Hanzawaia concentrica* (Cushman) forma *strattoni* Applin, *Hopkinsina pacifica* Cushman (Plate 2, Figures 9-10), *Lagena striata* (d'Orbigny) (Plate 2, Figures 13-14), *Rosalina bahamaensis* Todd and Law, *R. concinna* (Brady) (Plate 2, Figures 15-17), *R. subaraucana* (Cushman) (Plate 2, Figures 18-20).

Shelf Forms That Occur in Bays.
Buliminella cf. *B. bassendorfensis* Cushman and Parker, *B. elegantissima* (d'Orbigny), *Elphidium discoidale* (d'Orbigny) *translucens* Natland, *Florilus atlanticus* (Cushman), *Hanzawaia concentrica* (Cushman) forma *typica*.

Forms with a Similar Pattern of Occurrence to Shelf Forms of the Bay.
Bulimina tenuis Phleger and Parker.

Rare Shelf Forms.
Asterigerina carinata d'Orbigny, *Eponides repandus* (Fichtel and Moll), *Fursenkoina complanata* Egger, *Globulina caribaea* d'Orbigny, *Lagena tenuis* (Bornemann), *Planulina exorna* Phleger and Parker, *Reussella atlantica* Cushman, *Wisenerella auriculata* Egger.

Miscellaneous Species

Ammonia parkinsoniana tepida Secondary Biofacies.

Bucella hanni (Phleger and Parker), *Epistominella vitera* Parker, *Guttulina gibba* d'Orbigny, *Nonionella pulchella* Hada.

Rare Forms (less than 1 percent of fauna and observed at fewer than 13 locations).

Angulogerina carinata Cushman var. *bradyana* Cushman, *Articulina mayori* Cushman, *Cibicides mayori* (Cushman), *Nodosaria catsbyi* d'Orbigny, *Spirolina arietina* (Batsch).

Planktonic Species.

Globigerina bulloides d'Orbigny, *Globigerinoides ruber* d'Orbigny Cushman.

CONCLUSIONS

Ammonia is the dominant genus at 75 percent of the statistically valid stations in St. Andrew Bay. It defines the *Ammonia* biofacies, which includes all of the Bay except a few scattered, small intertidal localities. An *Ammonia* biofacies is an established estuarine biofacies of the Gulf of Mexico.

Ammonia parkinsoniana is the dominant species at all *Ammonia* dominant stations. *Ammonia parkinsoniana tepida* Cushman is dominant in the central, deeper, more saline, warmer, subtidal areas, whereas *A. parkinsoniana typica* Poag is dominant in the peripheral shallow, less saline, cooler intertidal areas. The two ecophenotypes define the *A. parkinsoniana tepida* secondary biofacies of the subtidal bottoms and *A. parkinsoniana typica* secondary biofacies of the intertidal bottoms.

The remaining stations are dominated by *Elphidium* (10 percent), miliolids (9 percent), and agglutinated forms (5 percent). The principal *Elphidium* are ecophenotypes of *E. galvestonense* and *E. gunteri,* which are more abundant in the intertidal areas, but do not show the relationships to salinity and temperature reported for them elsewhere (Poag, 1978). Three other *Elphidium* were classified as shelf or bay forms. *Elphidium* is the most abundant genus in polluted areas.

Miliolids are more diverse (23 species) than *Elphidium* but are minor elements (rarely exceding 5 percent) of most populations. Some species are more abundant in intertidal areas, but most occur in both intertidal and tidal areas. All but one of the species are bay forms.

Agglutinated forms are dominant at only 5 percent of the stations, which are intertidal. Most of the species are more abundant in the intertidal areas, although all but one of the nine species occur in rarity at scattered subtidal stations. One agglutinated species is subtidal and another is part of the shelf fauna.

Species typical of the shelf are numerous (29) but are uncommon to rare (less than 10 percent) in most populations. Several species increase in numbers toward, and form an axial pattern of distribution along the deepest, most saline, and warmest parts of the Bay. Apparently their distribution results from flood tidal currents that transport meroplanktonic larval stages into, and possibly replace, unviable communities in the Bay. Distributional patterns of some species suggest concentration by constricted ebb tide currents on exposed Pleistocene shelf sediments. Except for this possibility, no correlation was found between sediment size and foraminiferal distribution.

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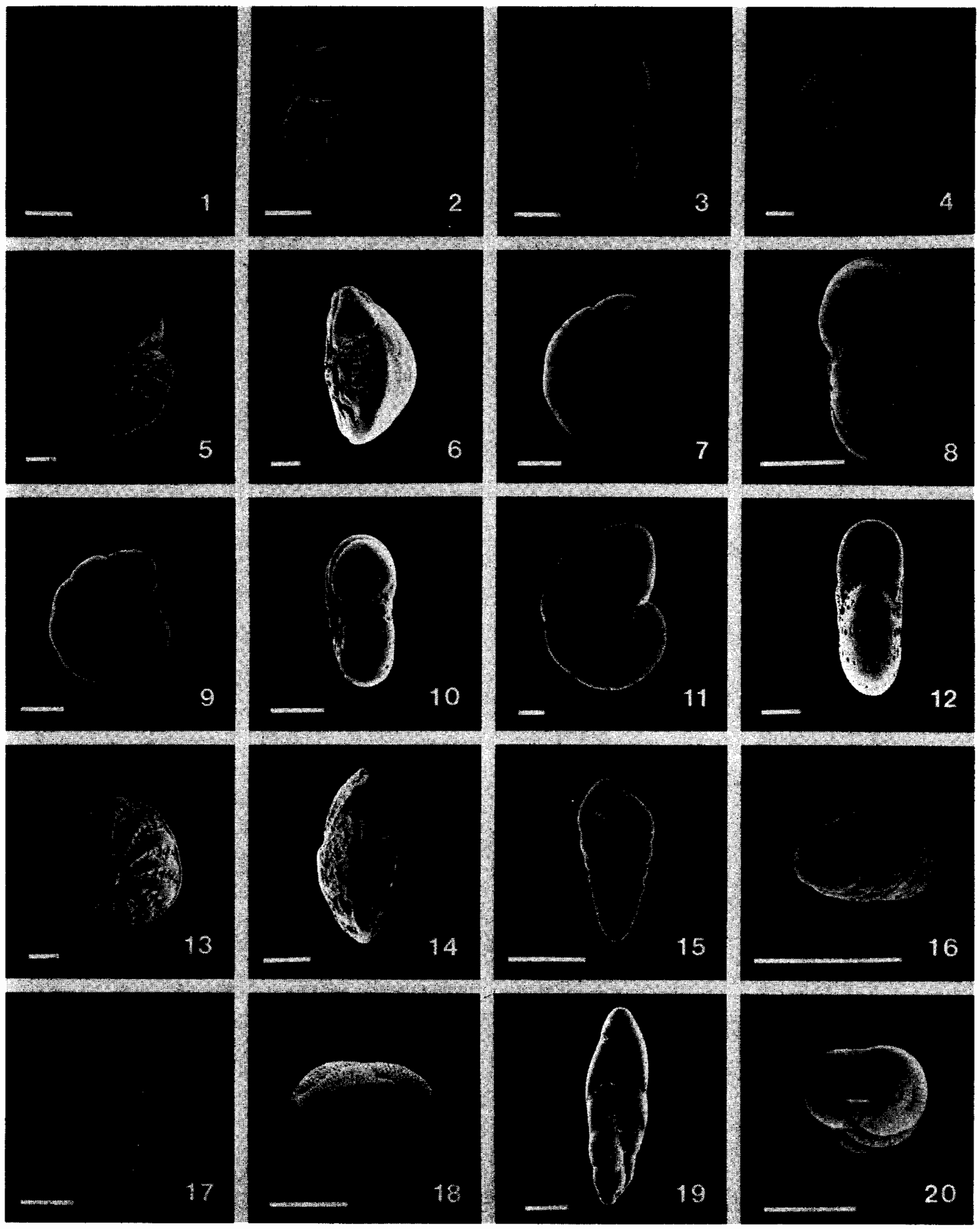

Plate 1

Bar scale = 100 microns

FIGURE

1-3 *Ammonia parkinsoniana* (d'Orbigny) forma *tepida* Cushman. 1, spiral view. 2, umbilical view. 3, edge view. Station 525.

4-6 *Ammonia parkinsoniana* (d'Orbigny) forma *typica* Poag. 4, spiral view. 5, umbilical view. 6, edge view. Station 30.

7-8 *Elphidium gunteri* Cole forma *salsum* Cushman and Brönnimann. 7, side view. 8, edge view. Station 539.

9-10 *Elphidium galvestonense* Kornfeld *mexicanum* Kornfeld. 9, side view. 10, edge view. Station 576.

11-12 *Elphidium poeyanum* (d'Orbigny). 11, side view. 12, edge view. Station 576.

13-14 *Elphidium fimbriatulum* (Cushman). 13, side view. 14, edge view. Station 576.

15-16 *Brizalina lowmani* (Phleger and Parker). 15, side view. 16, apertural view. Station 546.

17-18 *Brizalina striatula* (Cushman). 17, side view. 18, apertural view. Station 526.

19-20 *Fursenkoina pontoni* (Cushman). 19, side view. 20, apertural view. Station 523.

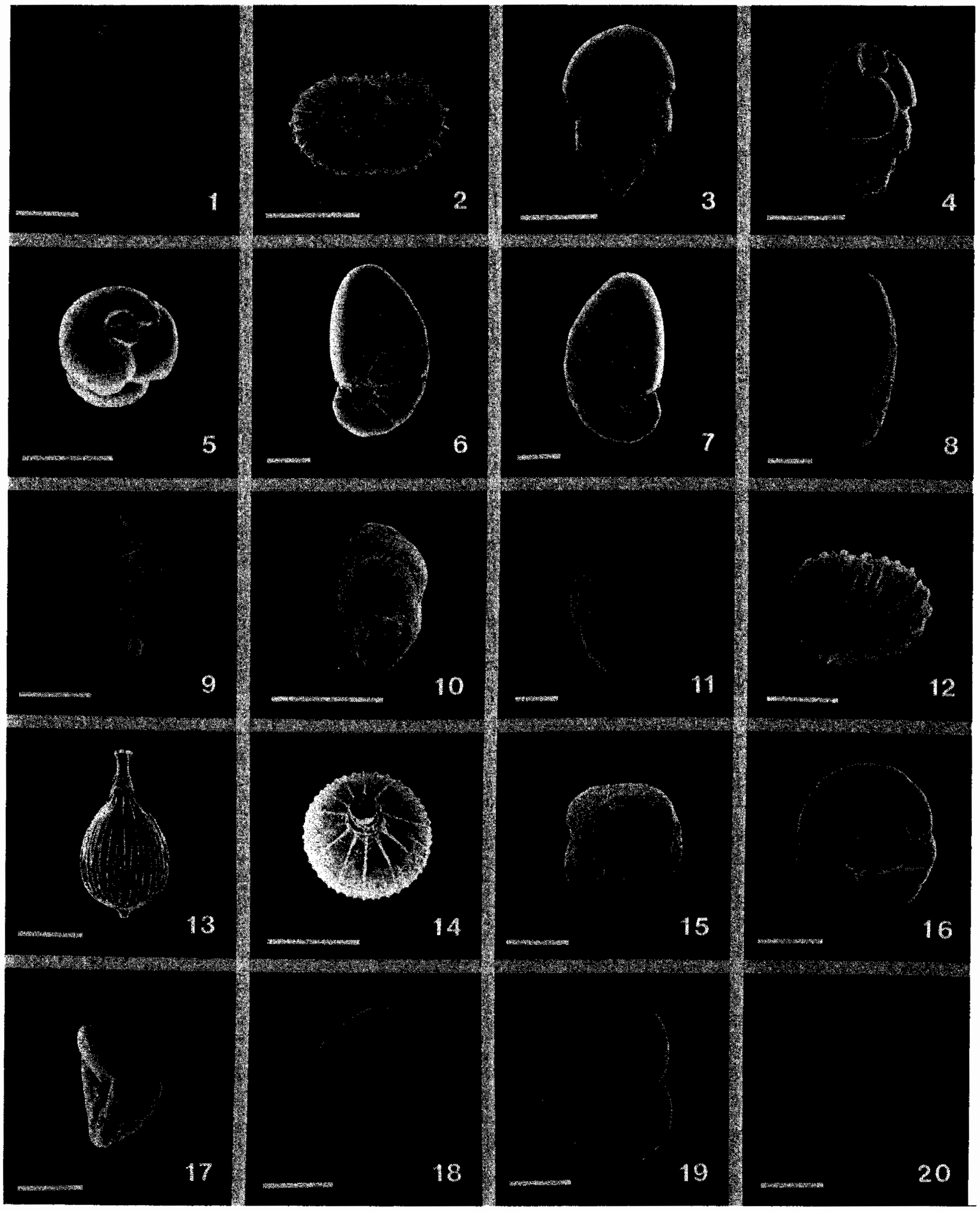

Plate 2

Bar scale = 100 micron

FIGURE

1-2 *Fursenkoina spinicostata* (Phleger and Parker). 1, side view. 2, apertural view. Station 230.

3-5 *Bulimina marginata* d'Orbigny. 3-4, side views. 5, apertural view. Station 246.

6-8 *Florilus atlanticus* (Cushman). 6-7, opposite views. 8, edge view. Station 525.

9-10 *Hopkinsina pacifica* Cushman. 9, side view. 10, apertural view. Station 576.

11-12 *Guttulina australis* (d'Orbigny). 11, side view. 12, apertural view. Station 592.

13-14 *Lagena striata* (d'Orbigny). 13, side view. 14, apertural view. Station 523.

15-17 *Rosalina concinna* (Brady). 15, spiral view. 16, umbilical view. 17, side view. Station 592.

18-20 *Rosalina subaraucana* (Cushman). 18, spiral view. 19, umbilical view. 20, edge view. Station 592.